ELECTROPHORETIC APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates to an electrophoretic apparatus for analyzing a small amount of protein, nucleic acid, drugs, and the like, and more particularly to an electrophoretic apparatus using an electrophoretic member having a plate-shaped member in which is formed one or a plurality of passages through which a specimen migrates electrophoretically.

Description of the Related Art

Conventionally, an electrophoretic apparatus has been used to analyze an extremely small amount of protein, nucleic acid or the like, represented by a capillary electrophoretic apparatus. In the capillary electrophoretic apparatus, a glass-made capillary (hereinafter called capillary also) with an inner diameter of 100 μm or less is filled with an electrophoretic medium and then has a specimen introduced at one end thereof and has its both ends wetted with a buffer liquid, through which is applied a high voltage between the two ends in order to develop an analysis-subject substance in the capillary. The capillary has a large surface area as compared to its volume, that is, has a high cooling efficiency, so that a high voltage can be applied on it, thus qualifying it for use in analysis of an extremely small amount of a specimen such as DNA (deoxyribo-nucleic acid) at a high speed and a high resolution.

The capillary has a small outer diameter of about 100-500 μm and is easily broken, thus having a problem that the user finds it difficult to replace it. Also, sometimes it may have insufficient heat radiation, which has an adverse effect on a separated state. Furthermore, since a voltage is applied between the ends of the capillary through a buffer liquid, it needs to have at least an extra length required for wetting with the buffer solution, thus bringing about a problem that it must have a certain design length.

To guard against this, there has been proposed such an aspect replacing a capillary that may be improved in analysis speed and apparatus size, disclosed in

an item of D. J. Harrison et al./Anal. Chem. 1993, 283, 361–366, which describes an electrophoretic member (hereinafter called electrophoretic chip also) which is formed by connecting two substrates. An example of the electrophoretic chip is shown in FIG. 14.

An electrophoretic chip 221 is comprised of one pair of substrates 221a and 221b made of a transparent plate–shaped inorganic material (e.g., glass, quartz, silicon or the like) or plastic in such a configuration that, using a photolithographic technology used in manufacturing of semiconductor devices or a micro–machining technology, mutually intersecting electrophoretic capillary channels 223 and 225 are formed in one substrate 221b and, in the other substrate 221a, through–holes are formed as an anode reservoir 227a, a cathode reservoir 227c, a specimen reservoir 227s, and a waste reservoir 227w at positions corresponding to the ends of these channels 223 and 225. The electrophoretic chip 221 is used in such a state as shown in FIG. 14C, where the substrates 221a and 221b are connected on one another. Such an electrophoretic chip has thus two channels as formed to intersect with each other and, therefore, is also called a cross–channel type electrophoretic chip.

When using this electrophoretic chip 221 for electrophoresis, prior to analysis, an electrophoretic medium is delivered under pressure by, for example, a syringe to fill the channels 223 and 225 and the reservoirs 227a, 227c, 227s, and 227w from, for example, the anode reservoir 227a. Subsequently, the electrophoretic medium injected in the reservoirs 227a, 227c, 227s, and 227w is removed to then inject a specimen into the specimen reservoir 227s corresponding to one end of the shorter channel (specimen injection passage) 223 and a buffer solution into the other specimen reservoirs 227a, 227c, and 227w.

The electrophoretic chip 221 filled with the electrophoretic medium, the specimen, and the buffer liquid is mounted to an electrophoretic apparatus. Predetermined voltages are applied on the reservoirs 227a, 227c, 227s, and 227w to cause the specimen to electrophoretically migrate through the passage 223 up to an intersection 229 of the passages 223 and 225. The voltages applied on the reservoirs 227a, 227c, 227s, and 227w are switched so that a voltage applied between the reservoirs 227a and 227c at the ends of the longer channel

(separation passage) 225 may cause the specimen present at the intersection 229 to be injected into the passage 225. After this injection, the specimen contained in the reservoir 227s is replaced by the buffer liquid. After that, electrophoretic voltages are applied on the reservoirs 227a, 227c, 227s, and 227w to separate the specimen thus injected into the passage 225 in this passage 225. A detector, disposed at a proper position along the passage 225, is used to detect a specimen thus separated by electrophoresis. It is specifically detected using a absorptiometric, fluoro-metric, electro-chemical, or electric-conductivity method.

Also, such analysis conditions as a design of the passages in the electrophoretic chip or a composition of the electrophoretic medium depend on use and specimens. An electrophoretic chip having a different design of the passages is described in, for example, a repot of Yining Shi et al./Anal. Chem. 1999, 71, 5354-5361, in which the electrophoretic chip is provided with many separation passages formed therein in a radial manner.

Also, such an electrophoretic chip is available that has straight channels having no intersection therebetween.

An electrophoretic apparatus using in analysis such an electrophoretic chip that has only one separation passage as shown in FIG. 14 has a poor analysis efficiency, thus suffering from a problem that it is not suitable for simultaneous analysis, which is desired recently, of multiple test-specimens.

SUMMARY OF THE INVENTION

It is the first object of the invention to provide an electrophoretic apparatus which can analyze multiple test-specimens even with such an electrophoretic member that has a simple configuration of passages.

In order to attain the first object, one aspect of an electrophoretic apparatus of the invention uses an electrophoretic member in which one or a plurality of passages are formed inside a plate-shaped member of which holes are formed reaching these passages at positions corresponding to the ends of each of these passages and includes a voltage application part for applying a voltage across the passages in the electrophoretic member, a detector part for detecting a specimen present in the passages in the electrophoretic member, and an